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IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to an image forming apparatus utilizing an electrophotographic process, an electrostatic recording process etc.

Related Background Art

(1) Image forming process

10 An image forming apparatus is generally provided, as shown in Fig. 8, with a photosensitive drum 10 constituting a latent image bearing member, a charging apparatus 11 constituting charging means which uniformly charges the photosensitive drum, an
15 exposure apparatus 12 for applying an imagewise exposure to the uniformly charged photosensitive drum thereby forming an electrostatic latent image, a developing apparatus 13 for developing the electrostatic latent image with a toner, constituting
20 a developer, thereby obtaining a visible toner image, a transfer apparatus 15 constituting transfer means which transfers the toner image, present on the photosensitive drum, onto a transfer material 14 constituting a transfer medium, a fixing apparatus 16
25 for fixing the toner image on the transfer material, and a cleaning apparatus 17 constituting cleaning means which scrapes off a toner remaining on the

photosensitive drum 10. The photosensitive drum 10,
the charging apparatus 11, the developing apparatus
13 and the cleaning apparatus 17 are often
constructed as a process cartridge, detachably
5 mounted on a main body of the image forming apparatus.

The image forming apparatus executes an image
formation by repeating the steps of charging,
exposure, development, transfer, fixation and
cleaning with the above-mentioned means.

10 (2) Operation sequence of image forming apparatus

Fig. 9 shows a general operation sequence of an
image forming apparatus.

When a detachable process cartridge is inserted
into a main body of the image forming apparatus and a
15 power supply therein is turned on, a main motor is
activated to initiate an initial multi rotation step.
This step executes a detection of presence/absence of
the process cartridge, and a cleaning of a transfer
roller (toner attached on the transfer roller being
20 discharged onto the photosensitive drum).

After the initial multi rotation step, the
image forming apparatus moves a stand-by state. When
image information is supplied from output means such
as an unillustrated host computer to the image
25 forming apparatus, the main motor drives the main
body of the image forming apparatus thereby entering
an initial rotation step. This step executes

preparatory operations for printing in various process devices, principally including a preliminary charging of the photosensitive drum, a start-up of a laser scanner, a determination of a transfer voltage
5 in the image formation, and a temperature regulation of the fixing apparatus.

After the initial rotation step, an image forming step is initiated, including a supply of a transfer material at a predetermined timing, an
10 imagewise exposure on the photosensitive drum, a development, a transfer, a fixation etc.

After the image forming step, in case a next print signal is present, there is entered an intersheet step for awaiting a next printing
15 operation until a next transfer material arrives. In case of absence of a next print signal, the image forming apparatus enters a post-rotation step, which executes a charge elimination of the surface of the photosensitive drum, and a cleaning of the transfer
20 roller.

When the post-rotation step is completed, the image forming apparatus enters a stand-by state again, thus waiting for a next print signal.

(3) Charging apparatus and control method for
25 charging bias voltage

For the charging apparatus 11, there is widely employed a contact charging method of maintaining a

charging apparatus of roller or blade shape into contact with the surface of the photosensitive drum and applying a voltage to the charging apparatus thereby charging the surface of the photosensitive drum. In particular, the charging method of roller type can achieve a stable charging over a prolonged period.

A charging bias voltage source applies a charging bias voltage to the charging apparatus. The charging on the photosensitive drum may be achieved by a charging bias voltage constituted solely of a direct current voltage, but there is generally employed a bias voltage, as disclosed in Japanese Patent Application Laid-open No. 63-149669, formed by superposing a direct current voltage V_{dc} corresponding to a desired dark potential V_d on the drum with an alternating current voltage having a peak-to-peak voltage (V_{pp}) equal to or higher than two times of a discharge starting voltage under a direct current voltage application. (In the following, a direct current is represented by DC, an alternating current is represented by AC, and the above-described charging method is represented as AC+DC charging.)

This charging method is suitable for uniformly charging the surface of the photosensitive drum 10. By superposing the DC voltage with an AC voltage

equal to or higher than a certain level, a local potential unevenness (charging failure) on the photosensitive drum is eliminated by a leveling effect of the AC voltage, whereby a charged potential
5 Vd on the surface of the photosensitive drum uniformly converges to DC voltage Vdc.

The AC+DC charging is characterized in having a larger discharge current to the photosensitive drum, in comparison with a DC charging in which a DC
10 voltage alone is applied. With an increase in the discharge current to the photosensitive drum, a chain connecting molecules on the surface of the photosensitive drum tends to become more easily cleavable. Consequently a resin constituting the
15 surface of the photosensitive drum is modified toward a lower molecular weight, and becomes more easily scrapable with a cleaning blade. Therefore the surface of the photosensitive drum is polished and can enter a next image formation (charging step),
20 even after repeated use, in a refreshed state as in an initial stage of use without a surface contamination for example by a transfer residual toner.

However, in case an excessive discharge current
25 continues to be applied to the surface of the photosensitive drum, a surface layer of the photosensitive drum is scraped off with a higher

speed, whereby the photosensitive layer of the photosensitive drum reaches a limit film thickness where the photosensitive layer can no longer exhibit its function in an early stage after the start of use, thus coming to the end of the service life. Upon reaching such limit film thickness, the photosensitive layer loses its function, thus exhibiting a small unevenness in the charging, or generating a charging failure as a result of a loss in the charge holding ability of the surface. In the actual use, therefore, the discharge current to the surface of the photosensitive drum has to be so regulated as not to become excessively large.

A relation between a peak-to-peak value V_{pp} of the AC voltage and the discharge current is not constant but is influenced for example by an environment of use (a change in the impedance of the charging roller), a thickness of a charge transport layer of the photosensitive drum etc. For example, even under an application of an AC voltage of a constant peak-to-peak value V_{pp} , the discharge amount decreases in an environment of a low temperature and a low humidity because of an increase in the impedance of the charging roller, and increases in an environment of a high temperature and a high humidity because of a decrease in the impedance of the charging roller. Also under a same environment of

use, when the surface of the photosensitive drum is scraped off by the cleaning blade during the use, the discharge amount increases because the impedance becomes lower than at the initial stage of use.

5 In order to avoid such drawback, USP No. 5,420,671 proposes a method of controlling the AC component with a constant current. This method is to detect an AC current I_{ac} from the charging roller to the photosensitive drum and to control such current
10 at a constant level, and can maintain the discharge current substantially constant since the peak-to-peak value V_{pp} of the AC voltage changes flexibly in response to changes in the impedances of the charging roller and the photosensitive drum. This method is
15 very effective in securing a satisfactory charging property and preventing an excessive discharge to the photosensitive drum.

 This method requires, however, in order to obtain a stable bias voltage, to separate power
20 supplies for the AC and DC components to be superposed, thus necessitating two voltage-elevating transformers. Within a power supply circuit, a voltage-elevating transformer is a component relatively large and relatively costly. For this
25 reason, particularly in a compact and low-cost image forming apparatus, it has been desired to realize a stable charging bias voltage utilizing single

voltage-elevating means, not dependent on an environment of use or of a thickness of the photosensitive drum, thereby providing the photosensitive with a stable discharge current.

5 Therefore, it is proposed, as described in US Patent Application Publication No. 2003219268, to provide a stable discharge current by a charging bias supply circuit involving single voltage-elevating means, not dependent on the environment of use. Such
10 configuration will be explained in the following.

Fig. 10 is a schematic view of a charging bias supply circuit. It is based on a constant voltage control having plural AC oscillation outputs (V_{pp-1} , V_{pp-2} , ..., V_{pp-n} ; wherein peak-to-peak voltages have
15 a following relation $V_{pp-1} > V_{pp-2} > \dots > V_{pp-n} > \dots$), and utilizes only one voltage-elevating transformer for generating an AC component, and a DC is generated by a peak charging of a capacitor C_{10} by such voltage-elevating transformer.

20 An engine controller applies, from such AC oscillation outputs, the AC voltages with plural peak-to-peak voltage V_{pp} , and selects, as a peak-to-peak voltage of the charging AC voltage at the image formation, such a minimum V_{pp} that provides an AC
25 current I_{ac} in the photosensitive drum 10 equal to or larger than a peak-to-peak voltage selection control threshold current I_{ac-0} required for a charging AC

voltage not inducing a charging failure.

Such charging bias voltage control allows to obtain a substantially constant current behavior, as in a constant current control, independent from a
5 change in the impedance in the charging roller, the photosensitive drum etc.

Such charging voltage control method will be called a peak-to-peak voltage selection control.

(4) Elimination of foreign substance on
10 photosensitive drum

As explained in the foregoing, the surface of the photosensitive drum is maintained, even after repeated use, in a refreshed state equivalent to an initial state by polishing with a cleaning blade, and
15 can enter a next image formation (charging step) without a contamination for example by a transfer residual toner.

A foreign substance such as the transfer residual toner is usually scraped off in a post-
20 rotation step after an image formation. However, if a deposited foreign substance is in a state not easily separable from the surface of the photosensitive drum, a polishing in the post-rotation step and an initial rotation step in a next job may
25 be insufficient for removing such foreign substance. A printing process executed with an uneliminated foreign substance may result in an image defect

resulting from such foreign substance. A following phenomenon is an example of such situation.

Referring to Fig. 11, after an end of an image forming process, a foreign substance 19 such as a transfer residual toner or a power scraped off from the photosensitive drum is positioned between the cleaning blade 17 and the photosensitive drum 10, and is pressed to the photosensitive drum 10 by the pressure of the cleaning blade 17, thus becoming not easily separable. A position X on the photosensitive drum where the foreign substance is deposited becomes different in a friction coefficient, in comparison with other positions (free from the foreign substance) on the photosensitive drum. When a next image forming process is initiated in this state and the position X reaches the cleaning blade 17 after one turn, the rotating speed of the photosensitive drum 10 becomes different only in the position X since it is different in the friction coefficient in comparison with other points. Therefore an exposure blur is generated in an exposure position Y, leading to a white streak image uniform in the longitudinal direction, as shown in Fig. 12. Then, when this position again reaches the position of the cleaning blade, a same phenomenon is repeated whereby white streak images are generated at a period R corresponding to a peripheral length of the

photosensitive drum.

Since the deposited foreign substance 19 is scraped off little by little by the cleaning blade 17, the white streak image is most conspicuous in a first
5 print where the amount of the foreign substance is largest, then, in a continuous use, becomes progressively less conspicuous in a second print, a third print and so forth since the foreign substance is gradually scraped off, and eventually vanishes
10 completely as the foreign substance is eventually removed completely.

Therefore, this phenomenon can be resolved by extending a rotation time of the photosensitive drum prior to the image formation. An extension of the
15 rotation time of the photosensitive drum before the image formation increases the chance that the position with deposited foreign substance passes under the cleaning blade, thereby completely eliminating the foreign substance eventually.

20 However, in case of executing a peak-to-peak voltage selection control for the charging AC voltage and extending the photosensitive drum rotation time for completely eliminating the foreign substance from the photosensitive drum, there is required a longer
25 time before the image formation and the time required for the entire printing process results in a significant elongation, which is undesirable from the

standpoint of usability.

The present invention is to solve the
aforementioned drawbacks.

5 SUMMARY OF THE INVENTION

An object of the present invention is to
prevent generation of an image defect resulting from
a charging failure.

10 An object of the present invention is to supply
a stable discharge current at a charging operation,
irrespective of an environment for use.

An object of the present invention is to
completely eliminate a foreign substance, thereby
constantly providing a satisfactory image.

15 An object of the present invention is to
prevent a reduction in the service life of an image
bearing member.

20 An object of the present invention is to supply
a stable discharge current at a charging operation,
irrespective of an environment for use, and to
shorten the time of an entire printing process while
completely eliminating a foreign substance, thereby
constantly providing a satisfactory image.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sequence chart of an embodiment 2;

Fig. 2A is a chart showing a relation between a

sequence of an embodiment 1 and a potential on a photosensitive drum;

Fig. 2B is a chart showing a relation between a sequence of a comparative example 1 and a potential
5 on a photosensitive drum;

Fig. 3 is a view showing an image forming apparatus of the embodiment 1;

Fig. 4 is a flow chart showing an operation sequence of the image forming apparatus of the
10 embodiment 1;

Fig. 5 is a diagram showing a charging bias supply circuit of the embodiment 1;

Fig. 6 is a flow chart showing a charging bias selecting method in an initial rotation in an
15 embodiment 3;

Fig. 7A is a sequence chart of the embodiment 2;

Fig. 7B is a flow chart showing steps before the start of an initial rotation in the embodiment 2;

20 Fig. 8 is a view showing a prior image forming apparatus;

Fig. 9 is a flow chart showing an operation sequence of the prior image forming apparatus;

Fig. 10 is a view showing a charging bias
25 supply circuit in a peak-to-peak voltage selection for a charging AC voltage;

Fig. 11 is a view showing a white streak image

resulting from a foreign substance deposited on the surface of the photosensitive (view No. 1);

Fig. 12 is a view showing a white streak image resulting from a foreign substance deposited on the
5 surface of the photosensitive (view No. 2);

Fig. 13 is a view showing a layer structure of a photosensitive drum;

Fig. 14A is a chart showing an operation sequence of an image forming apparatus of the
10 embodiment 2;

Fig. 14B is a chart showing an operation sequence of an image forming apparatus of a comparative example 2;

Fig. 15 is a chart showing general AC voltage-current characteristics in a state where a contact charging roller is in contact with a photosensitive
15 drum;

Fig. 16 is a chart showing a relationship between a discharge current and a potential on a
20 photosensitive drum;

Fig. 17 is a chart showing a charging sequence in an embodiment 4;

Fig. 18 is a graph showing an experimental result for a foreign substance eliminating effect in
25 the embodiment 4; and

Fig. 19 is a sequence chart of the embodiment 2 showing results of the service life of the

photosensitive drum in the embodiment 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

5 (1) Image forming process

At first, an image forming apparatus employed in the present embodiment will be outlined. It is provided, as shown in Fig. 3, with a photosensitive drum 10 constituting a latent image bearing member, a charging roller 11 constituting charging means which uniformly charges the photosensitive drum 10, an exposure apparatus 12 for applying an imagewise exposure to the uniformly charged photosensitive drum thereby forming an electrostatic latent image, a developing apparatus 13 for developing the electrostatic latent image with a toner 13-a constituting a developer thereby obtaining a visible toner image, a transfer apparatus 15 for transferring the developed toner image onto a transfer material 14 constituting a transfer medium, a fixing apparatus 16 for fixing the toner image transferred onto the transfer material 14, and a cleaning apparatus 17 for scraping off a toner remaining on the photosensitive drum 10.

25 The cylindrical photosensitive drum 10 constituting the latent image bearing member is a negatively chargeable organic photosensitive member,

and is rotated in a direction indicated by an arrow by an unillustrated motor in a main body of the image forming apparatus.

The charging roller 11 constituting the
5 charging means is pressed toward a center of the photosensitive drum 10, and is rotated by the rotation thereof. The charging roller 11 is given a charging bias voltage from an unillustrated charging bias supply circuit, to be explained later. The
10 charging bias voltage employs a method of superposing a DC voltage V_{dc} corresponding to a desired potential V_d on the drum with an AC voltage having a peak-to-peak voltage (V_{pp}) equal to or higher than a discharge starting voltage. Such charging method
15 intends, by superposing a DC voltage and an AC voltage, to resolve local potential unevenness on the photosensitive drum, and to uniformly charge the photosensitive drum to a potential V_d equal to the applied DC voltage V_{dc} .

20 The exposure apparatus 12 is to form an electrostatic latent image on the uniformly charged photosensitive drum 10, and is constituted, in the present embodiment, of a semiconductor laser scanner. The exposure apparatus applies an imagewise exposure
25 to the photosensitive drum, corresponding to an image signal transmitted from an unillustrated host apparatus in the image forming apparatus. On the

surface of the photosensitive drum, an exposed part assumes a lower absolute value of the potential in comparison with the absolute value of the charged potential, whereby an electrostatic latent image
5 corresponding to the image information is formed in succession.

The developing apparatus 13 develops the electrostatic latent image on the photosensitive drum 10 with the toner 13-a constituting the developer,
10 thereby rendering the electrostatic latent image visible (reversal development), and employs a jumping development in the present embodiment. In this method, a developing bias voltage formed by superposing an AC voltage and a DC voltage and
15 supplied from an unillustrated developing bias source is applied to a developing sleeve, whereby the toner 13-a, frictionally charged negatively in a contact portion of a developer thickness regulating member 13-b and the developing sleeve 13-c, executes a
20 reversal development of the electrostatic latent image on the photosensitive drum.

The transfer roller 15 constituting the transfer means transfers the toner image, developed on the photosensitive drum 10, onto a transfer
25 material 14 such as paper, and is pressed toward the center of the photosensitive drum 10 by unillustrated biasing means such as a pressing spring. When a

transfer step is initiated by a conveying of the transfer material 14, a positive DC transfer bias voltage is applied from an unillustrated transfer bias source to the transfer roller 15 whereby the
5 negatively charged toner on the photosensitive drum 10 is transferred onto the transfer material 14.

The transfer bias is of a polarity opposite to the charging polarity of the toner. Namely, in case the toner is negatively charged, a positive transfer
10 bias is employed, and, in case the toner is positively charged, a negative transfer bias is employed.

In the present embodiment, since the toner is charged negatively, there is employed a positive
15 transfer bias.

The fixing means 16 fixes the toner image, transferred onto the transfer material 14, into a permanent image for example with heat and pressure. The permanent image after fixation is discharged to
20 the exterior of the main body of the image forming apparatus.

The cleaning blade 17 constituting the cleaning apparatus recovers a transfer residual toner which has not been transferred completely at the transfer
25 step from the photosensitive drum 10 to the transfer material 14, and is maintained in contact with the photosensitive drum 10 under a constant pressure and

recovers the transfer residual toner thereby cleaning the surface of the photosensitive drum. After the cleaning step, the surface of the photosensitive drum enters again the charging step.

- 5 The image forming apparatus executes image formation by repeating the steps of charging, exposure, development, transfer, fixation and cleaning, utilizing the aforementioned means.

- A process cartridge C includes the
10 photosensitive drum 10, the charging roller 11, the developing apparatus 13 and the cleaning apparatus 17, and is detachably mounted on the main body of the image forming apparatus. The mounting and the detachment of the process cartridge C are executed by
15 opening a door (not shown) provided in the main body of the image forming apparatus.

(2) Photosensitive drum

- Referring to Fig. 13, the photosensitive drum
10 constituting the latent image bearing member is formed by providing, on a substrate 10a of a hollow
20 aluminum cylinder of a diameter of 20 to 50 mm, an undercoat layer 10b, a charge generation layer 10c and a charge transport layer 10d in succession.

- The undercoat layer 10b is provided for the
25 purposes of improving adhesion of the charge generation layer, improving a coating property, protecting the substrate, covering a defect on the

substrate, improving a charge injecting property from the substrate and protecting the photosensitive layer from an electrical destruction, and has a thickness of about 0.2 to 2.0 μm .

5 The charge generation layer 10c is formed by sufficiently dispersing a charge generating pigment with a binder resin of an amount of 0.5 to 4 times and a solvent, and coating and drying the dispersion.

10 The charge transport layer 10d is formed by dissolving a charge transporting substance and polycarbonate resin or the like in a solvent and coating the solution on the charge generation layer. In general, the strength of a resin decreases with a decrease in the molecular weight, and, in case of
15 polycarbonate resin, the strength becomes insufficient for an average molecular weight $M < 5000$, so that the polycarbonate resin ordinarily employed has an average molecular weight $M \geq 5000$.

(3) Operation sequence of printer

20 In the following, an operation sequence of the printer of the present embodiment will be explained with reference to Fig. 4.

(1) Initial multi rotation step

25 When a power supply is turned on in the main body of the image forming apparatus, a main motor is activated to initiate an initial rotation, thereby initializing the image forming apparatus (such step

being hereinafter called initial multi rotation).

The initial multi rotation is executed when the power supply is turned on, and, in case a print signal is supplied to the image forming apparatus in a stand-by state after a printing process, the operation is started from an initial rotation step to be explained next.

(2) Initial rotation step

When a print signal is supplied from output means such as an unillustrated host computer to the image forming apparatus, the unillustrated main motor drives the main body of the image forming apparatus thereby entering an initial rotation step. This step executes preparatory operations for printing in various process devices, principally including a preliminary charging of the photosensitive drum, a start-up of the laser scanner, a determination of a transfer bias, and a temperature regulation of the fixing apparatus.

(3) Print step and inter-sheet step

In a printing step, there are executed steps of a charging, an imagewise exposure and a development in an area constituting an image forming area, and a toner image formed on the drum is transferred onto a transfer material such as paper. After the printing step, in case a next print signal is present, there is entered an intersheet step until a next transfer

material arrives, thereby awaiting a next printing operation.

(4) Post-rotation step

In case of absence of a next print signal after
5 the end of the printing step, the image forming
apparatus enters a post-rotation step, which executes
a charge elimination of the surface of the
photosensitive drum, and a discharge of the toner
sticking to the transfer roller onto the
10 photosensitive drum (cleaning of the transfer roller).

When the post-rotation step is completed, the
image forming apparatus enters a stand-by state again,
thus waiting for a next print signal.

(4) Peak-to-peak voltage selection control for AC
15 charging voltage

Now there will be explained a peak-to-peak
voltage selection control for AC charging voltage
employed in the present embodiment. The peak-to-peak
voltage selection control is a control method of
20 suitably selecting a peak-to-peak voltage of the
charging AC voltage (charging peak-to-peak voltage)
to be applied to an image forming area for forming a
toner image to be transferred to the transfer medium,
thereby providing a stable discharge current
25 regardless of the environment of use, thus achieving
a uniform charging and preventing generation of an
image defect resulting from a charging failure.

4-1) Process from an AC current detection to a peak-to-peak voltage selection for charging AC voltage

A method for selecting a charging peak-to-peak voltage in the present embodiment will be explained with reference to Fig. 5.

A charging bias voltage source 1, which is a power supply circuit, can supply the charging roller 11 constituting the charging means with an AC and DC superposed voltage by means of single voltage-elevating means T1. The charging bias voltage source 1 constituting the power supply can stepwise apply two or more different peak-to-peak voltages.

The charging bias voltage source 1 applies a first AC voltage for the peak-to-peak voltage selection control (hereinafter called a peak-to-peak voltage selecting bias). The charging bias voltage source applies a charging bias voltage to the charging roller 11, utilizing the voltage-elevating means T1 etc., and selecting the peak-to-peak voltage selecting bias as V_{pp-1} , V_{pp-2} , ..., V_{pp-n} , $V_{pp-(n+1)}$, ... (wherein the peak-to-peak voltages have a magnitude relationship of $V_{pp-1} > V_{pp-2} > \dots > V_{pp-n} > V_{pp-(n+1)} > \dots$). In response an AC current I_{ac} flows to a ground terminal GND through the charging roller 11 and the photosensitive drum 10. An AC current detection circuit 9, constituting AC current

detection means, executes a sampling, in such AC current, of an AC current having a frequency same as a charging frequency by an unillustrated filter circuit formed by a resistor and a capacitor, and
5 converts it into a detection voltage V which is supplied to an engine controller. Thus the detection voltage V is entered, as information based on the AC current amount, into the engine controller. The detection voltage V, sampled at a predetermined
10 period, is averaged in the engine controller.

The averaged detection voltage V_{ave} is compared by comparison means in the engine controller, with a peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage, stored in
15 advance. The peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage is so selected as to correspond to a detection voltage detected by the AC current detection circuit and averaged when a minimum necessary current (peak-to-
20 peak voltage selection control threshold current for charging AC voltage) I_{ac-0} capable of uniform charging without unevenness flows from the charging roller through the photosensitive drum to the GND.

Since the value I_{ac-0} varies depending on the
25 process speed and the charging frequency of the apparatus, and the material constituting the charging roller 11 and the photosensitive drum 10, the peak-

to-peak voltage selection control threshold value V_0 for the charging AC voltage is preferably selected for each case.

4-2) Peak-to-peak voltage selection control for
5 charging AC voltage in initial rotation at the start of power supply (initial multi rotation)

When a power supply is turned on in the main body of the image forming apparatus, a main motor is activated to initiate an initial rotation (such step
10 being hereinafter called initial multi rotation). In this state, the engine controller of the main body of the image forming apparatus applies all the applicable AC voltages with different peak-to-peak voltages or a part thereof to the charging roller,
15 and executes such a control as to use, as the AC voltage for image formation, an AC voltage having a minimum peak-to-peak value for which a detection voltage obtained from an AC current flowing from the charging roller to the photosensitive drum is equal
20 to or larger than the peak-to-peak voltage selection control threshold value V_0 . For example, AC voltages are applied in an increasing order of the peak-to-peak voltage, such as $V_{pp-(n+2)}$, $V_{pp-(n+1)}$, V_{pp-n} , and $V_{pp-(n-1)}$ (magnitude of the peak-to-peak values
25 of the AC voltages being $V_{pp-(n+2)} < V_{pp-(n+1)} < V_{pp-n} < V_{pp-(n-1)}$). Since the magnitude of V_{pp} corresponds to that of the corresponding current I_{ac}

and that of the voltage detected by the AC current detection circuit, the respectively detected voltages V_{n+2} , V_{n+1} , V_n and V_{n-1} assume a magnitude relationship of $V_{n+2} < V_{n+1} < V_n < V_{n-1}$. In case a
5 relation $V_{n+2} < V_{n+1} < V_0 < V_n < V_{n-1}$ is obtained in connection with the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage, the peak-to-peak voltage for the charging AC voltage at image formation is selected at V_{pp-n} .
10 Stated differently, V_{n+2} or V_{n+1} does not provide a detection voltage equal to or larger than the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage, but V_n or V_{n-1} provides a detection voltage equal to or larger than the peak-
15 to-peak voltage selection control threshold value V_0 for the charging AC voltage. V_n is selected because it is the AC voltage having the minimum peak-to-peak value among V_n and V_{n-1} . The detection voltage may also be obtained by averaging detection voltages of
20 plural times. In this manner, in the initial multi rotation step, there is provided a first peak-to-peak voltage selecting step for selecting a peak-to-peak voltage capable of reaching a minimum necessary current enabling a uniform charging. Such step
25 allows a correction to an optimum peak-to-peak voltage at the start of power supply. In the foregoing explanation, for the ease of understanding,

the detection voltage is determined up to V_{n-1} beyond the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage, but the first peak-to-peak voltage selecting step may naturally be
5 terminated as soon as the detection voltage V_n , equal to or larger than the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage is obtained.

In this operation, each peak-to-peak voltage
10 selecting bias is preferably applied for a period at least equal to a turn of the latent image bearing member. The photosensitive drum may show an unevenness in the film thickness along the periphery for example due to an uneven scraping resulting from
15 an eccentric rotation, and the resulting AC current I_{ac} may show a fluctuation at the rotating period of the photosensitive drum, so that it is preferable to continue the application of the bias voltage for at least a turn of the photosensitive drum in order to
20 achieve a precise current detection. However, the application time of the bias voltage should not be made excessively long, since a longer application time extends the time of the entire process. In the present embodiment, the first peak-to-peak voltage
25 selecting step is executed at each start of the power supply, but such example is not restrictive. For example, the first peak-to-peak voltage selecting

step may be executed at a time other than the start of the power supply.

4-3) Peak-to-peak voltage selection control for charging AC voltage in initial rotation

5 The peak-to-peak voltage selection control for the charging AC voltage is preferably executed also in the initial rotation step prior to the image formation. This is because, in case the peak-to-peak voltage selection control for the charging AC voltage
10 is executed only in the initial multi rotation step at the start of power supply, an appropriate peak-to-peak voltage selection is not at all executed in an image forming apparatus not provided with the initial multi rotation step (for example an image forming
15 apparatus of which power supply is always turned on). However, the peak-to-peak voltage selecting step in the initial multi rotation step, explained in the foregoing 4-2), involves successive applications of the peak-to-peak voltage selecting biases and
20 requires a time.

As the film thickness of the photosensitive drum decreases with the progress of a durability run, a resulting current increases even under a voltage application same as that when the film thickness is
25 larger. In consideration of a positive relationship between the current and the voltage, the required peak-to-peak voltage may be made lower than the

previous one with the progress of the durability run.

Therefore, in the peak-to-peak voltage selection control after the initial multi rotation step, it is possible, by selecting a peak-to-peak voltage smaller than the peak-to-peak voltage selected in the preceding image formation as the peak-to-peak voltage selecting bias, to achieve a reduction in the control time in comparison with the peak-to-peak voltage selecting step in the initial multi rotation step, as explained in 4-2). Thus, in the initial rotation step, there is provided a second peak-to-peak voltage selecting step for selecting a peak-to-peak voltage before reaching the minimum necessary current required for charging.

In the initial rotation step, the selection of the peak-to-peak charging voltage is executed in a following procedure. Referring to Fig. 6, taking the peak-to-peak voltage for the image formation, determined in the peak-to-peak voltage selecting method for the charging AC voltage in the initial multi rotation step, as explained in 4-2), as V_{pp-n} , the initial rotation step applies only a voltage $V_{pp-(n+1)}$ which is lower than V_{pp-n} by one step.

It is possible to stepwise lower the peak-to-peak voltage of the appropriate AC voltage to be used for image formation, in consideration of the influence of scraping of the surface of the

photosensitive drum in use. It is therefore possible to execute a voltage switching at an appropriate timing by comparing a detection voltage V_{n+1} , corresponding to the application of $V_{pp-(n+1)}$, which is lower by one step than the currently employed charging peak-to-peak voltage V_{pp-n} , with the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage.

The detection voltage V_{n+1} is averaged by the operation means in the engine controller to provide an averaged detection voltage $V_{n+1-ave}$, which is compared by the comparison means with the peak-to-peak voltage selection control threshold value V_0 for the charging AC voltage. In case $V_{n+1-ave} < V_0$, V_{pp-n} is selected as the peak-to-peak voltage of the charging AC voltage for image formation, but, in case $V_{n+1-ave} > V_0$, the image formation is executed by switching the peak-to-peak voltage of the charging AC voltage to $V_{pp-(n+1)}$.

..... This method does not require the application of an unnecessary charging voltage and can be executed within a short time, so that the initial rotation time need not be extended.

(5) Sequence for foreign substance elimination on photosensitive drum

When the main motor is stopped after the image formation, a foreign substance such as a transfer

residual toner remaining principally in a contact position of the cleaning blade on the photosensitive drum causes a white streak image, uniform in the longitudinal direction, in a next image formation.

5 In order to avoid such phenomenon, it is possible to extend the initial rotation time as in the prior technology, but the present embodiment applies, as a bias for eliminating the foreign substance, a second AC voltage (hereinafter called a foreign substance
10 eliminating bias) having a peak-to-peak voltage larger than the peak-to-peak voltage of the peak-to-peak voltage selecting bias. The application of such foreign substance eliminating bias increases the
15 discharge current to the photosensitive drum, thereby facilitating a cleavage of a chain connecting molecules on the surface of the photosensitive drum. Consequently a resin constituting the surface of the photosensitive drum is modified toward a lower molecular weight, and becomes more easily scrapable
20 with the cleaning blade, so that the foreign substance deposited on the drum surface is also eliminated. As explained in the foregoing, the AC voltage for charging the image forming area is selected at a minimum necessary peak-to-peak voltage
25 by the peak-to-peak voltage selection control. Also, for the aforementioned reason, the peak-to-peak voltage of the peak-to-peak voltage selecting bias is

smaller than the peak-to-peak voltage of the AC voltage for charging the image forming area. Consequently, the peak-to-peak voltage selecting bias is not effective for eliminating the foreign substance. Therefore, the bias for foreign substance elimination is applied only in a partial time, such as the initial rotation, thereby eliminating the foreign substance prior to the image formation. The foreign substance eliminating bias is applied for at least a turn of the photosensitive drum, preferably for three turns of more. Also the foreign substance eliminating bias is preferably a peak-to-peak voltage of a maximum AC voltage applicable to the charging roller by the charging bias supply source.

Such foreign substance eliminating bias is preferably applied in a non-image forming area. More preferably it is applied in an initial rotation step immediately before the image formation. As the foreign substance deposited and becoming not easily removable at the end of a preceding job is effectively eliminated by the foreign substance eliminating bias before the start of the next image formation, so that the surface of the photosensitive drum is refreshed immediately before the image formation and can always provide a satisfactory image.

Also the peak-to-peak voltage of the foreign substance eliminating bias, if larger than the peak-

to-peak voltage of the AC voltage for charging the image forming area, can provide an effect of facilitating the scraping of the surface of the photosensitive drum.

5 (6) Charging sequence

Now let us consider an image forming apparatus characterized by the invention in that the charging AC voltage selecting bias and the foreign substance eliminating bias are both applied to the charging means at the initial rotation step. During the application of the charging AC voltage selecting bias, there may not be obtained a current necessary for charging, so that the potential V_d on the photosensitive drum does not completely reach the desired drum potential V_d but remains unstable. On the other hand, under the application of the foreign substance eliminating bias, which is larger than the charging bias at the image formation, the potential V_d on the photosensitive drum becomes stabilized.

20 Fig. 2 shows a relationship between the peak-to-peak voltage selecting sequence and the potential on the photosensitive drum.

Referring to Fig. 2A showing an embodiment of the present invention, the potential on the photosensitive drum does not reach the desired value during the peak-to-peak voltage selecting step (S2-S3), but becomes stabilized to the desired value when

the foreign substance eliminating bias V_{pp-1} is applied, so that the image formation can be started immediately after (S4) the end of application of the foreign substance eliminating bias V_{pp-1} .

5 Then, as a comparative example 1, there was considered a case of inverting the order of applications as shown in Fig. 2B, namely applying the foreign substance eliminating bias at first (S6-S7) and then executing the peak-to-peak voltage selecting
10 step (S7-S8). In such case, the potential V_d on the photosensitive, which is stabilized during the application of the foreign substance eliminating bias (S6-S7), becomes unstable in the peak-to-peak voltage selecting step (S7-S8). In order to avoid such
15 situation, the image formation may be started after applying a charging AC voltage for image formation during an additional turn (S8-S9) of the photosensitive drum thereby achieving a preliminary charging (S9), but such method requires an extension
20 of the initial rotation step by a time T_5 , thus requiring an additional time for image formation.

 Thus, the extension of the initial rotation step as in the comparative example 1 can be dispensed with by executing, in the initial rotation step, the
25 charging bias selecting step at first and then executing the application of the foreign substance eliminating bias, as in the example 1.

As explained in the foregoing, by applying a first AC voltage for selecting the charging peak-to-peak voltage at first and then applying a second AC voltage for foreign substance elimination, it is
5 rendered possible to supply a stable discharge current at the charging operation irrespective of the environment of use, and to eliminate the foreign substance thereby constantly providing a satisfactory image. Also the entire printing process can be
10 limited within a short time.

In the present embodiment, there has been explained a case of applying the foreign substance eliminating bias after the second peak-to-peak voltage selecting step, but, also in case of applying
15 the foreign substance eliminating bias after the first peak-to-peak voltage selecting step, the aforementioned effects can be obtained by applying the foreign substance eliminating bias after the application of the first AC voltage for the charging
20 peak-to-peak voltage selection. Even in the first peak-to-peak voltage selecting step, the application of an AC voltage incapable of providing a current necessary for the charging (for example such AC voltage as $V_{pp}-(n+2)$ or $V_{pp}-(n+1)$ explained in 4-2))
25 causes an unstable potential area on the photosensitive drum, so that the application of the foreign substance eliminating bias after the peak-to-

peak voltage selecting step enables the supply of a stable discharge current and a reduction in the printing process time.

Embodiment 2

5 (1) Transfer bias control

The present embodiment relates to an image forming apparatus employing an active transfer voltage control (hereinafter called ATVC) for controlling the transfer current supplied to the transfer apparatus, constituting the transfer means. The ATVC will be explained later.

At first an explanation will be given on the transfer apparatus and the method for controlling the transfer bias voltage.

15 The transfer apparatus principally employs a contact transfer method in which the transfer apparatus is pressed to the latent image bearing member thereby executing a transfer to the transfer material constituting the transfer medium, and within
20 such method, there is principally employed a roller transfer method which is superior in conveying property for the transfer material at the transfer unit. In the roller transfer method, a transfer roller is pressed to the photosensitive drum under a
25 total pressure of 4.9 to 19.6 N (0.5 to 2.0 kg) to form a transfer nip between the photosensitive drum and the transfer roller, and, while the transfer

material is nipped and conveyed in such transfer nip, a toner image on the photosensitive drum is transferred onto the transfer material under a bias voltage applied to the transfer roller.

5 In an image forming apparatus provided with transfer means of contact type (for example a copying machine or a laser beam printer), the transfer bias supplied to the contact transfer member is generally subjected to a constant voltage control or a constant
10 current control.

 In the constant voltage control, because the transfer roller employed as the contact transfer member shows a change of a significant order in the resistance by the environmental conditions, it is
15 difficult to constantly apply a stable transfer bias regardless of the environment.

 On the other hand, the constant current control can resolve the aforementioned drawback resulting from the change in the resistance of the transfer
20 roller and can always secure a charge amount necessary for the transfer. However, since the image forming apparatus of the aforementioned type is usually so designed as to accept transfer materials of various sizes, in case a transfer material of a
25 smaller size is passed, a sheet non-passing area where the photosensitive drum and the transfer member are in direct contact becomes wider and passes most

of the current, whereby the transfer charge becomes deficient and leads to a transfer failure particularly in an environment of a low temperature and a low humidity.

- 5 In order to avoid such drawback, there is proposed a method ATVC for achieving an optimum current at the sheet passing.

For example, a constant current control is executed in a sheet non-passing state where a
10 transfer material is absent in the transfer position, and a voltage in such state is held and used for executing a constant voltage control when a sheet is passed.

More specifically, a constant current is
15 supplied to a dark portion (Vd portion) of the photosensitive drum showing a constant value to monitor a generated voltage, and such voltage is used for controlling the applied bias under certain operations such as (1) a same value, (2) multiplied
20 by a factor, (3) added by a fixed voltage etc., thereby providing a certain effect in preventing fluctuation in the transfer property resulting from an environmental fluctuation or a difference in the size of the transfer material.

- 25 Also there is known a method of monitoring a current flowing between the photosensitive drum and the charging member under the application of

different transfer voltages, and employing a transfer voltage providing an optimum current as the transfer voltage in sheet passing.

(2) Charging/transfer sequence in embodiment 2

5 The sequence of charging and transfer in the present embodiment will be explained. During the initial rotation step, the peak-to-peak voltage selection for the charging AC voltage is executed at first and the application of the foreign substance
10 eliminating bias is executed later as in the example 1. The present embodiment is characterized in that a positive transfer voltage for controlling the transfer voltage is applied after an area of the photosensitive drum, charged by the foreign substance
15 eliminating bias, arrives at a contact portion with the transfer apparatus (transfer position). In the following description, portions same as in the embodiment 1 will be omitted.

 In the charging/transfer sequence during the
20 initial rotation step as shown in Fig. 1, the method of applying the peak-to-peak voltage selecting bias and the foreign substance eliminating bias is same as that in the embodiment 1.

 As explained in the embodiment 1, during the
25 application of the peak-to-peak voltage selecting bias, a current necessary for charging cannot be obtained, so that the potential V_d on the

photosensitive drum does not completely reach the desired drum potential V_d but remains unstable, but the potential V_d on the photosensitive drum becomes stabilized when the foreign substance eliminating bias is applied.

Referring to Fig. 14A showing the configuration of the embodiment 2, the potential on the photosensitive drum does not reach the desired value during the peak-to-peak voltage selecting step (S2-S3), but becomes stabilized to the desired value when the foreign substance eliminating bias V_{pp-1} is applied, so that the image formation can be started immediately after (S4) the end of application of the foreign substance eliminating bias V_{pp-1} . During the peak-to-peak voltage selecting step (S2-S3) for the photosensitive drum, as the positive transfer voltage is not applied, the photosensitive drum is prevented from a situation where it is charged positively by the transfer voltage thereby generating a memory in the photosensitive layer on the surface of the photosensitive drum. Also as an application of a positive voltage for transfer voltage control is executed in an area having a stable potential V_d on the photosensitive drum, the transfer voltage control can be executed in a more stable manner. In the present embodiment, a weak transfer bias for the transfer voltage control is applied (S3-S4) in all

the area where the foreign substance eliminating bias is applied, but it may also be applied in a part of the area where the foreign substance eliminating bias is applied.

5 In a comparative example 2, a positive transfer voltage (weak bias) is applied, for the transfer control as in ATVC, during the peak-to-peak voltage selecting step (S7-S8) as shown in Fig. 14B. In this case, since the positive transfer voltage is applied
10 in an area having an unstable potential V_d on the photosensitive drum, the photosensitive drum is positively charged under the influence of the transfer voltage. Therefore, in case an image formation is started immediately after (S8) the end
15 of the peak-to-peak voltage selecting step, such positively charged area cannot assume a sufficient potential V_d during a first turn (S8-S9) of the photosensitive immediately after the start of image formation, thereby causing a defective charging in
20 such area (S8-S9). Also an error may be generated in the transfer voltage control since the control is executed in an unstable area. In order to avoid such situation, the transfer bias for the transfer voltage control may be applied after applying a charging bias
25 for image formation during an additional turn (S8-S9) of the photosensitive drum thereby achieving a preliminary charging (S9), but such method requires

an extension of the initial rotation step by a time T5, thus requiring an additional time for the image formation.

In the present embodiment, the positive
5 transfer voltage for the transfer voltage control is applied when an area of the photosensitive drum, charged by the application of the foreign substance eliminating bias, is positioned in a contact position with the transfer apparatus (transfer position),
10 thereby realizing effects of reducing the time of the initial rotation step and preventing the defective charging caused by the positive charging of the photosensitive drum.

The embodiment 2 utilizes the application of
15 the transfer voltage for the purpose of transfer voltage control, but the present invention is also applicable in a case of applying a transfer bias, which has a polarity opposite to the normal charging polarity of the photosensitive drum and may generate
20 a memory in the image bearing member, such as a transfer bias for eliminating the foreign substance on the transfer member. More specifically, even in case of applying the transfer bias to the transfer means in an area of the image bearing member charged
25 by the application of the foreign substance eliminating bias (namely an area with stable potential V_d on the photosensitive drum), it is

possible to avoid a memory generation in the photosensitive layer of the photosensitive drum, whereby a satisfactory charging property can be obtained in the subsequent image forming step.

5 Also with respect to the prevention of memory generation in the photosensitive layer of the photosensitive drum, the effects of the present invention can be obtained also when the peak-to-peak voltage selecting bias is not applied. More
10 specifically, also in case of applying, for the purpose of foreign substance elimination, an AC voltage for a non-image forming area having a peak-to-peak voltage larger than the peak-to-peak voltage of the charging AC voltage for charging the image
15 forming area and then applying a transfer bias for ATVC in an area of the photosensitive drum charged by such AC voltage for the non-image forming area, it is possible to avoid a memory generation in the photosensitive layer of the photosensitive drum,
20 whereby a satisfactory charging property can be obtained in the subsequent image forming step. In the embodiment 2, since the foreign substance eliminating bias constituting the second AC voltage has a peak-to-peak voltage larger than that of the
25 charging AC voltage, such second AC voltage also constitutes, stated differently, the AC voltage for the non-image forming area.

Embodiment 3

The present embodiment relates to an image forming apparatus having, in a same main body, a special mode in which an initial rotation time is
5 extended than in the normal state.

In the present embodiment, the image forming process and the charging bias control method are same as those in the embodiment 1 and will not, therefore, be explained further.

10 When image information is supplied from output means such as a host computer to the image forming apparatus, a main motor drives the image forming apparatus thereby entering an initial rotation step. This step executes preparatory operations for
15 printing in various process devices, principally including a preliminary charging of the photosensitive drum, a start-up of the laser scanner, a determination of a transfer voltage, and a temperature regulation of the fixing apparatus.

20 The initial rotation step in a normal mode is limited to a predetermined time for executing the aforementioned regulations, but may be extended in a certain special situation.

For example, the fixing apparatus may vary the
25 fixing temperature thereof according to the type of the transfer material, in order to satisfactorily fix the toner image regardless of the type of the

transfer material. For example, in case of printing on a heavier paper thicker than an ordinary paper, it is necessary to elevate the fixing temperature by about 5 to 20°C in comparison with the printing on an ordinary paper, and the initial rotation time is extended as a longer time is required for temperature elevation for the temperature control at a higher temperature.

Figs. 7A and 7B show an operation sequence chart of a main motor, a charging and a transfer of the image forming apparatus of the present embodiment, and a flow chart thereof, respectively in a mode with an ordinary transfer material and in an initial rotation extending mode for example in case of passing a thick paper as explained above.

Referring to Fig. 7B, when the user of the image forming apparatus determines a print mode for example depending on the kind of the transfer material and turns on a print signal, a fixing temperature of the fixing apparatus is determined in the main body of the image forming apparatus, according to thus determined print mode.

Then, there is discriminated whether such fixing temperature can be processed in the initial rotation time of the normal mode. In case the initial rotation time of the normal mode is enough, a charging bias application time in the initial

rotation step is set at $T6+T7$, which is a charging bias application time of a normal initial rotation mode as shown in Fig. 7A, and the initial rotation is initiated.

- 5 On the other hand, in case the initial rotation time requires an extension, the main body of the image forming apparatus determines a time $T8$ necessary for regulating the temperature of the fixing device as shown in Fig. 7B, then sets the
- 10 charging bias application time at $T6+T7+T8$, and initiates the initial rotation.

- When the initial rotation is started, as to the charging bias, a peak-to-peak voltage selecting bias is applied at first, and a foreign substance
- 15 eliminating bias is applied later. The applications in such sequence are to prevent a charging failure in the image formation, as already explained in the embodiment 1.

- Also a peak-to-peak voltage selecting bias is
- 20 applied for a time $T6$ same as in the normal mode (corresponding to one turn of the photosensitive drum), and a peak-to-peak voltage of a maximum applicable AC voltage (foreign substance eliminating bias) is applied for a time of $T7+T8$, which is
- 25 extended by $T8$ from the case of the normal mode. In this manner, the surface of the photosensitive drum has more opportunities of polishing immediately

before the image formation, and is more refreshed at the image formation, thereby enabling a satisfactory image formation.

Also in case of executing ATVC control or the like as in the embodiment 2, the weak bias application for ATVC control is extended for T8. Since an application of a strong positive voltage such as a print bias to the photosensitive drum may generate a memory on the surface thereof by a positive charging, the application of the print bias is preferably executed at S14 immediately before the image formation, thereby minimizing the time of application of such high positive voltage.

Embodiment 4

This embodiment defines a discharged charge amount caused by the foreign substance eliminating bias employed in the embodiments 1 to 3, thereby improving a foreign substance eliminating property on the drum surface. Other configurations are same as those in the embodiment 1 and will not, therefore, be explained further.

(1) Discharged charge amount δ per unit area

There will be given an explanation on a discharged charge amount δ ($\mu\text{A} \times \text{sec}/\text{m}^2$) (hereinafter δ being simply represented as discharged charge amount). Also an "AC charge amount ρ per unit area ($\mu\text{A} \times \text{sec}/\text{m}^2$)" is an amount defined by:

$$\rho [\mu\text{A} \times \text{sec}/\text{m}^2] = I_{ac}/L/V_{ps}$$

wherein I_{ac} (μA) is a current flowing in the photosensitive drum, V_{ps} (m/sec) is a moving speed of the photosensitive drum, and L (m) is a longitudinal
5 length of a charging area, and it is hereinafter simply represented as the AC charge amount.

Referring to Fig. 15 showing general charging characteristics of a charging roller between a peak-to-peak voltage V_{pp} (V) of a vibrating component
10 represented on the abscissa and an AC charge amount ρ ($\mu\text{A} \times \text{sec}/\text{m}^2$) represented on the coordinate, the AC charge amount ρ increases linearly within a range of V_{pp} from zero to a twice of a charging start voltage V_{th} . An inclination of this linear line indicates an
15 AC admittance. In a region beyond twice of V_{th} , the relationship of the two is no longer linear and the inclination increases with an increase in V_{pp} . Such increase in the inclination is due to an increase in the AC charge amount ρ caused by the start of a
20 discharge.

Therefore, the discharged charge amount δ at a peak-to-peak voltage V_{pp} of the applied voltage in a region beyond twice of V_{th} is represented by:

$$\delta [\mu\text{A} \times \text{sec}/\text{m}^2] = (I_{ac} - \alpha \times V_{pp})/L/V_{ps}$$

25 wherein α represents an AC admittance, which is a ratio of current to a voltage not exceeding twice of the discharge starting voltage V_{th} .

(2) Discharged charged amount and polishing effect
for the surface of photosensitive drum

As explained in the foregoing, an increase in
the discharged charge amount to the photosensitive
5 drum facilitates a cleavage of a chain connecting
molecules on the surface of the photosensitive drum.
Consequently a resin constituting the surface of the
photosensitive drum is modified toward a lower
molecular weight, and becomes more easily scrapable
10 with the cleaning blade. Since the discharge current
and the discharged charge amount have a positive
correlation, an increase in the polishing effect on
the surface of the photosensitive drum can be
achieved by applying a larger discharged charge
15 amount δ on the surface of the photosensitive drum,
thereby facilitating the scraping of the surface.

However, in case an excessively high discharged
charge amount continues to be applied to the surface
of the photosensitive drum, a scraping speed of the
20 surface layer of the photosensitive drum increases in
the course of continued use of the apparatus, and the
photosensitive layer upon reaching a limit thickness
loses its function thereby generating a local
charging unevenness or a charging failure as a result
25 of a decrease in the charge holding ability of the
surface. Consequently the service life of the image
forming apparatus and the process cartridge is

limited by a number of prints until the photosensitive layer is abraded to the limit film thickness.

Fig. 16 shows a relationship between a
5 discharged charge amount δ and a surface potential V_d of the photosensitive drum, found experimentally by the present inventors.

The surface potential V_d of the photosensitive drum, as a function of the discharged charge amount δ
10 per unit area ($\mu A \times \text{sec}/m^2$), is stabilized from 175 ($\mu A \times \text{sec}/m^2$), but a range of 175 to 1200 ($\mu A \times \text{sec}/m^2$) is undesirable for selection as a discharged charge amount of the charging AC voltage for charging the image forming area, because of presence of local
15 spot-shaped weakly charged portions, which appear as black spots or white spots on the image. In a range of δ beyond 1200 ($\mu A \times \text{sec}/m^2$), such weakly charged portions disappear so that the photosensitive drum can be uniformly charged.

20 Therefore, the discharged charge amount δ_b of the charging AC voltage for charging an area to constitute an image forming area is preferably selected larger than 1200 ($\mu A \times \text{sec}/m^2$) but as close as possible to 1200 ($\mu A \times \text{sec}/m^2$).

25 (3) Control mechanism

In the present embodiment, control is made on the discharged charge amount of the foreign substance

eliminating bias of the embodiment 1 and the discharged charge amount of the charging AC voltage.

Referring to Fig. 17 showing a charging bias applying sequence of the embodiment 4 of the present invention (however excluding the peak-to-peak voltage selecting step), the initial rotation step is provided with a sequence T for applying the foreign substance eliminating bias to the photosensitive drum, and a discharged charge amount δ_a during this sequence T is larger than a discharged charge amount δ_b during a printing process. This is intended to apply a strong discharge to the photosensitive drum in the initial rotation step, thereby increasing the polishing effect for the surface of the photosensitive drum immediately before the image formation and securely eliminating the foreign substance. Therefore, the foreign substance eliminating sequence is so designed that a portion to be subjected to foreign substance elimination passes the charging roller at least once.

Also in this sequence, there is calculated in advance a relation between the AC charge amount p and the discharged charge amount δ , and such an AC voltage as to obtain an appropriate discharged charge amount is applied.

(4) Evaluation

Following experiment was executed in order to

confirm the effect of the present sequence.

Experiment 1

Experiment for confirming a foreign substance
eliminating ability on the surface of the

5 photosensitive drum

A portion with deposited foreign substance was
made to pass through the charging roller three times,
under following conditions, during the sequence T of
application of the foreign substance eliminating bias,
10 and a number of white streaks generated at an
interval of the periphery of the photosensitive drum,
on a halftone image (1 dot-1 space lateral line:
resolution 600 dpi).

Conditions

15 environment: high temperature and high humidity
(room temperature 35°C, 85 %RH)

photosensitive drum moving speed Vps: 130 (mm/sec)

resolution of main body of image forming

apparatus: 600 (dpi)

20 charging bias voltage: AC current control

AC current Iac of foreign substance eliminating
bias: 600 - 850 (μ A)

discharged charge amount δa of foreign substance
eliminating bias: 1280 - 5400 (μ A \times sec/m²)

25 AC current Iac' of charging AC voltage: 600 (μ A)

discharged charge amount δb of charging AC voltage:
1280 (μ A)

charging AC frequency f : 900 (Hz)

photosensitive drum diameter ϕ : 28 (mm)

surface layer of photosensitive drum:

polycarbonate resin with an average molecular weight

5 M = 15000, in which a charge transporting agent is dispersed

contact pressure of cleaning blade to photosensitive drum: 40 (gf/cm)

transfer material: a transfer material of a

10 longitudinal length \times transversal length = 1500 \times 216 (mm) being passed

Result of experiment 1 (Embodiment 4-a)

In Fig. 18, the abscissa indicates a discharged charge amount δa per unit area during the sequence T
15 for applying the foreign substance eliminating bias, and the ordinate indicates a number of white streaks appearing on the image.

These results confirmed a significant effect, as a larger discharged charge amount δa increased the
20 polishing effect on the photosensitive drum to achieve a faster vanishing of the white streaks, and particularly as the white streak generation could be completely avoided in a range $\delta a \geq 2600$ ($\mu A \times \text{sec}/m^2$).

Also an increase in the average molecular
25 weight M of the surface of the photosensitive drum renders the scraping more difficult, thereby rendering the removal of the foreign substance more difficult,

but the drum surface can be satisfactorily polished
in a range of the average molecular weight of the
surface of the photosensitive drum $M \leq 40000$, whereby
the effect of the foreign substance eliminating
5 sequence of the present embodiment appears clearly.

Experiment 2

Experiment for confirming a service life of the
photosensitive drum

A service life of the photosensitive drum was
10 confirmed under following conditions. The service
life of the photosensitive drum is defined by a
timing when the surface of the photosensitive drum
cannot be fully charged by a surface scraping of the
photosensitive drum thereby resulting in so-called
15 fog phenomenon in which a toner development is
generated in a solid white image portion.

[Conditions-1 (Embodiment 4-b)]

environment: high temperature and high humidity
(room temperature 35°C, 85 %RH)

20 photosensitive drum moving speed Vps: 130 (mm/sec)
resolution of main body of image forming
apparatus: 600 (dpi)

charging bias voltage: AC constant current control

AC current Iac of foreign substance eliminating

25 bias: 750 (μ A)

discharged charge amount δa of foreign substance
eliminating bias: 3260 (μ A \times sec/m²)

- AC current I_{ac}' of charging AC voltage: 600 (μA)
discharged charge amount δb of charging AC voltage:
1280 (μA)
charging AC frequency f : 900 (Hz)
- 5 photosensitive drum diameter ϕ : 28 (mm)
 surface layer of photosensitive drum: average
molecular weight $M = 15000$
 contact pressure of cleaning blade to
photosensitive drum: 40 (gf/cm)
- 10 evaluation mode: intermittent durability test by
one sheet each
 [Conditions-2 (Comparative Example 4-1)]
 AC current of charging AC voltage: 600 (μA :
constant)
- 15 discharged charge amount δb of charging AC voltage:
1280 ($\mu A \times \text{sec}/m^2$: constant)
 Other conditions are same as those in
condition-1.
 [Conditions-3 (Comparative Example 4-2)]
- 20 AC current I_{ac}' of charging AC voltage: 750 (μA :
constant).
 discharged charge amount δb of charging AC voltage:
3260 ($\mu A \times \text{sec}/m^2$: constant)
 Other conditions are same as those in
- 25 condition-1.

Results of Experiment 2

Fig. 19 shows the results of the experiment 2.

In a case with the sequence of the present embodiment, the photosensitive drum reached the end of the service life at 7000 sheets. On the other hand, the comparative example 1 with the least discharged charge amount showed the end of the service life at 7300 sheets. Also the comparative example 2 with the largest discharged charge amount showed the end of the service life at 5400 sheets.

These results indicate that the present embodiment does not shorten the service life of the photosensitive drum since the discharged charge amount is made larger only in a necessary portion.

In the configuration explained in the foregoing, a sequence for applying a foreign substance eliminating bias in a necessary portion is provided in the initial rotation step, thereby increasing the discharged charge amount in such portion, whereby the surface of the photosensitive drum is refreshed immediately before the image formation and does not generate an image defect resulting from a foreign substance deposited on the surface of the photosensitive drum.

Also a portion where the discharge current is increased is limited, whereby the surface of the photosensitive drum is not scraped off unnecessarily and the service life thereof is not shortened.